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County Lewis and Clark
Facility & # City of Helena #90
Closure / Landfarm
Finan Assur / Liner
GW Corr Meas / Methane
GW Monitoring / O & M
GW Reports / Run-on
Inspections
Other:

# TA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2011 GROUNDWATER QUALITY DATA

## CITY OF HELENA LANDFILL

**Prepared For:**

**CITY OF HELENA**
**HELENA, MONTANA**

**Hydrometrics, Inc.**
consulting scientists and engineers

**FEBRUARY 2012**

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DEPT. OF ENVIRO. QUALITY
WASTE & UNDERGROUND TANK
MANAGEMENT BUREAU

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**Hydrometrics, Inc.**
consulting scientists and engineers

3020 Bozeman Avenue
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**(406) 443-4150**
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February 28, 2012

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Mr. Martin Van Oort
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

RE: Statistical Evaluation of Decenber 2011 Groundwater Quality Data

Dear Martin,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in December 2011. After receiving approval from Pete Anderson of the City of Helena, I am forwarding a copy of the report "Data Validation and Statistical Evaluation of December 2011 Groundwater Quality Data City of Helena Landfill" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: John Rundquist, City of Helena, without Enclosure
Pete Anderson, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

# DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2011 GROUNDWATER QUALITY DATA

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## CITY OF HELENA LANDFILL

Prepared for:

Mr. John Rundquist
**City of Helena**
City/County Building
316 North Park Avenue
Helena, MT 59623

Prepared by:

**Hydrometrics, Inc.**
3020 Bozeman Avenue
Helena, MT 59601

February 2012

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# DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2011 GROUNDWATER QUALITY DATA

## CITY OF HELENA LANDFILL

### 1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the December 2011 monitoring event, summarizes, the data validation results and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.1305(8) and ARM 17.50.1305(9) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

# DATA VALIDATION AND STATISTICAL EVALUATION OF DECEMBER 2017 GROUNDWATER QUALITY DATA

## CITY OF HELENA LANDFILL

- Concentrations of PCE are decreasing over time in well EPA-1, the well that has historically shown the highest concentrations, and in compliance wells HL-90-1, HL-99-1, HL-99-2, and HL-99-3; and
- Elevated nitrate plus nitrite as N (nitrate) concentrations exist both upgradient and downgradient of the landfill at similar levels.

These findings are further evaluated in this December 2011 statistical report through an assessment of current concentrations (Table 4-1), a comparison of summary statistics (Tables 4-2 and 4-3), an inter-well prediction analysis (Table 4-4), and an examination of temporal trends (Table 4-5 and Figures 4-1 and 4-2).

# 2. SITE DESCRIPTION

## 2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater.

## 2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill were included in the December 2011 groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1, HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), eight of these wells were sampled during the December sampling event. The locations of these wells are shown in Figure 2-2.

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF DECEMBER 2011
GROUNDWATER QUALITY DATA

**VICINITY MAP**

FIGURE
**2-1**

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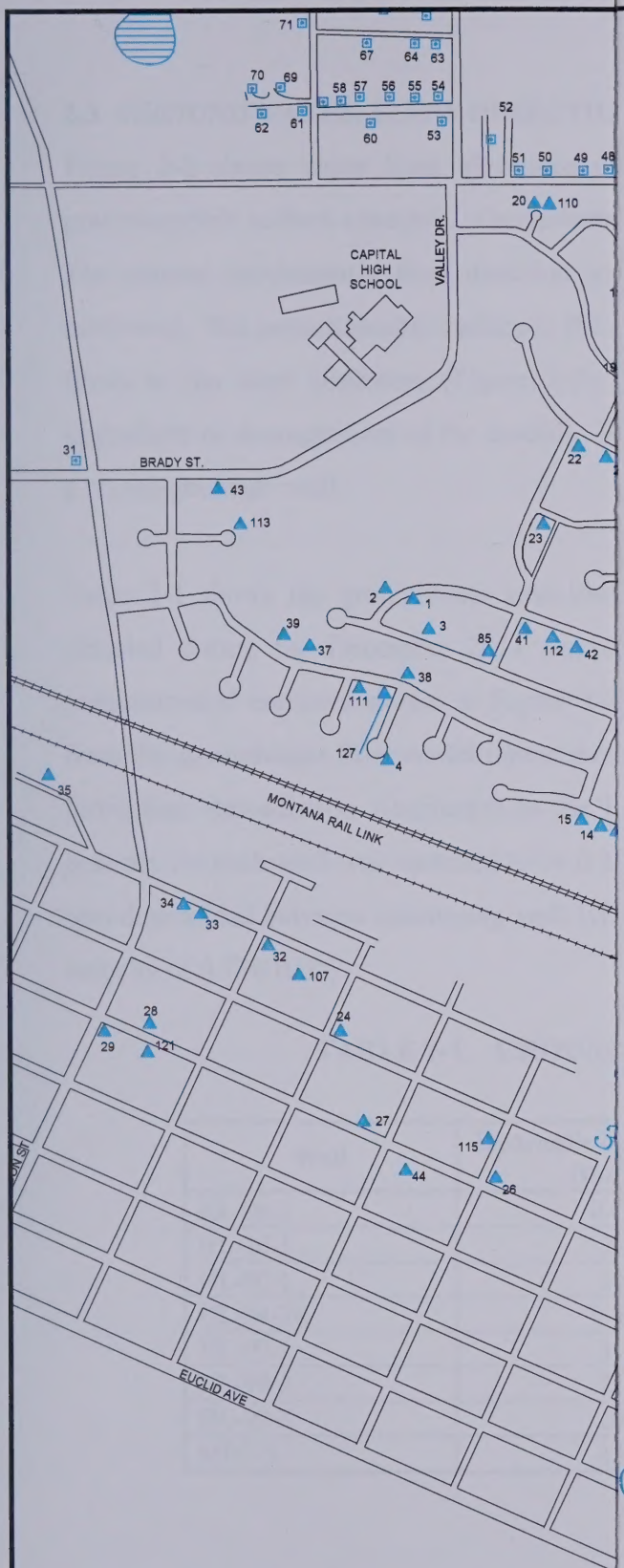
DATA VALIDATION & STATISTICAL
EVALUATION OF DECEMBER 2011
GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE
2-1




| SITE CODE | DTWL | MPE | SWL |
|---|---|---|---|
| Dec-11 | | | |
| HL-06-1 | 15.07 | 3993.62 | 3978.55 |
| 82-3 | 64.95 | 3973.51 | 3908.56 |
| EPA-1 | 45.08 | 3981.08 | 3936.00 |
| EPA-4 | No Access | 3973.83 | |
| HL-10-1 | 54.23 | 3943.01 | 3888.78 |
| HL-90-1 | 53.52 | 3942.48 | 3888.96 |
| HL-90-2 | 45.28 | 3950.96 | 3905.68 |
| HL-90-3 | 57.91 | 3958.29 | 3900.38 |
| HL-94-1R | 55.55 | 3994.04 | 3938.49 |
| HL-94-2R | 36.50 | 3967.64 | 3931.14 |
| HL-94-3 | 34.48 | 3967.38 | 3932.90 |
| HL-99-1 | 53.38 | 3943.15 | 3889.77 |
| HL-99-2 | 54.41 | 3945.75 | 3891.34 |
| HL-99-3 | 50.19 | 3948.05 | 3897.86 |
| INF. GALLE | 5.46 | 3918.89 | 3913.43 |
| I-1 | 63.05 | 3899.59 | 3836.54 |
| MPC-1 | 22.16 | 3946.08 | 3923.92 |
| MPC-2 | 16.89 | 3936.09 | 3919.20 |
| MPC-5 | 52.33 | 3990.14 | 3937.81 |

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# LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 ⊡ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 0 — POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

**UDY AREA AND DECEMBER 2011 POTENTIOMETRIC SURFACE**

FIGURE 2-2

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DATA VALIDATION & STATISTICAL
EVALUATION OF DECEMBER 2011
GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE
2-1

| SITE CODE | DTWL | MPE | SWL |
|---|---|---|---|
| Dec-11 | | | |
| HL-06-1 | 15.07 | 3993.62 | 3978.55 |
| 82-3 | 64.95 | 3973.51 | 3908.56 |
| EPA-1 | 45.08 | 3981.08 | 3936.00 |
| EPA-4 | No Access | 3973.83 | |
| HL-10-1 | 54.23 | 3943.01 | 3888.78 |
| HL-90-1 | 53.52 | 3942.48 | 3888.96 |
| HL-90-2 | 45.28 | 3950.96 | 3905.68 |
| HL-90-3 | 57.91 | 3958.29 | 3900.38 |
| HL-94-1R | 55.55 | 3994.04 | 3938.49 |
| HL-94-2R | 36.50 | 3967.64 | 3931.14 |
| HL-94-3 | 34.48 | 3967.38 | 3932.90 |
| HL-99-1 | 53.38 | 3943.15 | 3889.77 |
| HL-99-2 | 54.41 | 3945.75 | 3891.34 |
| HL-99-3 | 50.19 | 3948.05 | 3897.86 |
| INF. GALLE | 5.46 | 3918.89 | 3913.43 |
| I-1 | 63.05 | 3899.59 | 3836.54 |
| MPC-1 | 22.16 | 3946.08 | 3923.92 |
| MPC-2 | 16.89 | 3936.09 | 3919.20 |
| MPC-5 | 52.33 | 3990.14 | 3937.81 |

NORTH

SCALE
0 (In Feet) 800

## LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 ▣ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 3900 POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL EVALUATION OF DECEMBER 2011 GROUNDWATER QUALITY DATA

**STUDY AREA AND DECEMBER 2011 POTENTIOMETRIC SURFACE**

FIGURE 2-2

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## 2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in December 2011 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. The potentiometric surface in the area of well HL-94-3 suggests that groundwater flows to the west northwest (Figure 2-2); thus, well HL-94-3 is not considered to be upgradient or downgradient of the landfill. Well HL-94-3 has, therefore, been designated as a "cross-gradient" well.

Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the December 2011 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report "Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill" (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0237 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.770 ft/day.

**TABLE 2-1. GROUNDWATER VELOCITIES**

| Well | Hydraulic Conductivity (ft/day) | Slope (ft/ft) | Velocity (ft/day) |
|---|---|---|---|
| HL-06-1 | 0.03 | 0.0357 | 0.00428 |
| HL-10-1 | 20 | 0.0167 | 1.33 |
| HL-90-1 | 20 | 0.0167 | 1.33 |
| HL-94-2R | 0.28 | 0.0295 | 0.0330 |
| HL-99-1 | 10 | 0.0345 | 1.38 |
| HL-99-2 | 20 | 0.0142 | 1.13 |
| HL-99-3 | 20 | 0.0205 | 1.63 |
| MPC-5 | 2.8 | 0.0210 | 0.235 |

## 2.4 CURRENT ACTIVITIES

New modifications to Centennial Park, located over the old landfill, began in June 2010 and continued through the end of the summer of 2012. Construction work included the installation of fill material and some utilities, planting of new grass and trees, and the installation of a new automatic watering system and other park facilities. All modifications to the park were reviewed to ensure the integrity of the landfill cap would be maintained and that the final design would be even more protective of human health and the environment that the current design. All plans were submitted to MDEQ prior to construction. Every effort was made to preserve the existing monitoring wells and the corrective measures previously implemented.

Well EPA-1 was damaged during construction activities in the Spring of 2011. During the June 2011 sampling event, it was noted that although water level measurements could be taken, a bailer would no longer drop to the static water level of the well. Later, personnel from Hydrometrics and Helena Sand and Gravel were able to repair the well and the use of a bailer is again possible. This well was sampled again during the December 2011 sampling event.

## 3. SUMMARY OF DECEMBER 2011 DATA VALIDATION REPORT

Eight monitoring wells around the landfill and two domestic wells were included in the December 2011 sampling event. Static water levels (SWL) were obtained from eight additional monitoring wells, one irrigation well, and the infiltration gallery. The December 2011 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells 82-3 (SWL only), EPA-1 (SWL only), HL-06-1, HL-10-1, HL-90-1, HL-90-2 (SWL only), HL-90-3 (SWL only), HL-94-1R (SWL only), HL-94-2R, HL-94-3 (SWL only), HL-99-1, HL-99-2, HL-99-3, MPC-1 (SWL only), MPC-2 (SWL only), MPC-5;
- Irrigation wells I-1 (SWL only);
- Domestic wells 5, 16; and
- The infiltration gallery (SWL only).

The December analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells and volatile organics, semi-volatile organics, and halogenated organics for all domestic wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in December 2011 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). It was noted by the lab that upon receipt of the samples, sample HL-1112-200 did not have a collection time on the sample containers and the time was taken from other submitted documentation; and additional sulfuric acid was added to the nitrate bottle for sample HL-1112-109 to achieve the correct preservation requirement of pH<2. Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, a trip blank, a rinsate blank, and standard internal laboratory QC samples. No

parameters were reported as above the reporting limit in the D.I. blank or trip blank; however, the rinsate blank had an exceedance of chloroform resulting in one associated result being flagged. All field duplicate pair relative percent differences were within the required control limits. The entire data validation report is included as Appendix A of this report. Overall, the City of Helena Landfill data for December 2011 were deemed acceptable for the purposes of the project as outlined in the work plan.

# 4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the December 2011 sample results for the monitoring wells around the landfill. The domestic wells are evaluated separately in Section 5. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called "background") water quality with summary statistics of downgradient concentrations for December 2011 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the December 2011 sampling event. The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells sampled during the December 2011 sampling event, which have historically shown PCE results above the detection limit of 0.001 mg/L and nitrate results above the MCL of 10 mg/L or with potentially increasing trends, were evaluated.

## 4.1 DOWNGRADIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the December 2011 data and summary statistics in Tables 4-1, 4-2, and 4-3:

(a) For the December 2011 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (also called upgradient) wells: nickel, 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, m+p xylenes and total xylenes.

## TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS FOR THE DECEMBER 2011 MONITORING EVENT

| Parameter | Downgradient Wells | | | | | Upgradient Wells | | | MCL [1] |
|---|---|---|---|---|---|---|---|---|---|
| | HL-10-1 | HL-90-1 | HL-99-1 | HL-99-2 | HL-99-3 | HL-06-1 | MPC-5 | HL-94-1R | |
| pH (s.u.) | 7.0 | 7.5 | 7.3 | 7.4 | 7.9 | 7 | 7.1 | 7.6 | NA |
| Specific Conductance (µmhos/cm) | 1230 | 1100 | 1060 | 796 | 779 | 961 | 2170 | 768 | NA |
| Sulfate | 130 | 120 | 150 | 120 | 150 | 180 | 440 | 76 | NA |
| Chloride | 190 | 140 | 97 | 47 | 51 | 50 | 23 | 27 | NA |
| Nitrate+Nitrite as N | 8.9 | 8.8 | 9.4 | 6.6 | 8.3 | 8.9 | **12.3** | 0.55 | 10 |
| Arsenic (Dissolved) | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 | <0.005 | <0.005 | <0.005 | 0.010 |
| Iron (Dissolved) | <0.03 | <0.03 | 0.07 | 0.10 | 0.29 | <0.03 | **1.51** | <0.03 | 0.3 [2] |
| Nickel (Dissolved) | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.1 |
| Zinc (Dissolved) | <0.01 | <0.01 | 0.01 | 0.02 | 0.01 | <0.01 | <0.01 | <0.01 | 2 |
| 1,1,1-Trichloroethane | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0024 | <0.001 | <0.001 | 0.2 |
| 1,1-Dichloroethane | 0.0019 | 0.0017 | <0.001 | 0.0024 | 0.0011 | <0.001 | <0.001 | <0.001 | NA |
| Benzene | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | **0.037** | <0.001 | 0.005 |
| Bromodichloromethane | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0027 | 0.010 |
| Chloroform | <0.001 | <0.001 | 0.0021 | 0.0015 | 0.0019 | 0.0035 | <0.001 | 0.018 | 0.07 |
| Cis-1,2-Dichloroethene | 0.0016 | 0.0013 | 0.0016 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.07 |
| Dichlorodifluoromethane | 0.0016 | <0.001 | <0.001 | 0.0015 | <0.001 | <0.001 | <0.001 | <0.001 | 1 |
| Tetrachloroethene (PCE) | **0.0064** | **0.0057** | 0.0035 | 0.0049 | 0.0037 | <0.001 | <0.001 | <0.001 | 0.005 |
| Trichloroethene (TCE) | 0.0014 | 0.0012 | <0.001 | 0.0011 | <0.001 | <0.001 | <0.001 | <0.001 | 0.005 |
| o-Xylene | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.0035 | <0.001 | 10 [3] |
| m+p Xylene | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.011 | <0.001 | 10 [3] |
| Total Xylenes | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.015 | <0.001 | 10 |
| Cyanide (Total) | <0.005 | <0.005 | <0.005 | 0.007 | 0.033 | <0.005 | **5.05** | <0.005 | 0.2 |
| Chemical Oxygen Demand (COD) | 1 | 2 | 1 | <1 | 2 | <1 | 26 | 4 | NA |

**Concentrations are in mg/L, except as indicated.**

NM = not measured

(1) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies. NA indicates no MCL has been promulgated.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) MCL is for total xylenes.

Values in **bold** exceed the MCL.

## TABLE 4-2. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR THE DECEMBER 2011 SAMPLING EVENT

| Parameter | December 2011 Downgradient Well Concentrations (mg/L)[1] | | | | | | Comparison Values (mg/L) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Max. | Background / Upgradient Wells [2] | | | | |
| | D.F. [3] | Min. | Mean [4] | Median | Max. | Location | D.F. [3] | Mean [4] | Median | Max. | MCL [5] |
| pH (s.u.) | 5/5 | 7 | 7.42 | 7.4 | 7.9 | HL-99-3 | 3/3 | 7.23 | 7.1 | 7.6 | NA |
| Specific Conductance (µmhos/cm) | 5/5 | 779 | 993.0 | 1060 | 1230 | HL-10-1 | 3/3 | 1299.7 | 961 | 2170 | NA |
| Sulfate | 5/5 | 120 | 134.0 | 130 | 150 | HL-99-1 | 3/3 | 232.0 | 180 | 440 | NA |
| Chloride | 5/5 | 47 | 105.0 | 97 | 190 | HL-10-1 | 3/3 | 33.3 | 27 | 50 | NA |
| Nitrate+Nitrite as N | 5/5 | 6.6 | 8.40 | 8.8 | 9.4 | HL-99-1 | 3/3 | 7.25 | 8.9 | **12.3** | 10 |
| Arsenic (Dissolved) | 1/5 | <0.005 | 0.005 | <0.005 | 0.005 | HL-99-3 | 0/3 | 0.0050 | <0.005 | 0.005 | 0.010 |
| Iron (Dissolved) | 3/5 | <0.03 | 0.10 | 0.070 | 0.29 | HL-99-3 | 1/3 | **0.523** | <0.03 | **1.51** | 0.3[6] |
| Nickel (Dissolved) | 0/5 | <0.01 | <0.01 | <0.01 | <0.01 | NA | 1/3 | 0.013 | <0.01 | 0.02 | 0.10 |
| Zinc (Dissolved) | 3/5 | <0.01 | 0.01 | 0.010 | 0.02 | HL-99-2 | 0/3 | <0.01 | <0.01 | <0.01 | 2 |
| 1,1,1-Trichloroethane | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | 0.0015 | <0.001 | 0.0024 | 0.2 |
| 1,1-Dichloroethane | 4/5 | <0.001 | 0.0016 | 0.0017 | 0.0024 | HL-99-2 | 0/3 | <0.001 | <0.001 | <0.001 | NA |
| Benzene | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | **0.013** | <0.001 | **0.037** | 0.005 |
| Bromodichloromethane | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | 0.0016 | <0.001 | 0.0027 | 0.010 |
| Chloroform | 3/5 | <0.001 | 0.0015 | 0.0015 | 0.0021 | HL-99-1 | 2/3 | 0.0075 | 0.0035 | 0.018 | 0.07 |
| Cis-1,2-Dichloroethene | 3/5 | <0.001 | 0.0013 | 0.0013 | 0.0016 | HL-99-1 | 0/3 | <0.001 | <0.001 | <0.001 | 0.07 |
| Dichlorodifluoromethane | 2/5 | <0.001 | 0.0012 | <0.001 | 0.0016 | HL-99-2 | 0/3 | <0.001 | <0.001 | <0.001 | 1 |
| Tetrachloroethene (PCE) | 5/5 | 0.0032 | 0.0048 | 0.0049 | **0.0064** | HL-10-1 | 0/3 | <0.001 | <0.001 | <0.001 | 0.005 |
| Trichloroethene (TCE) | 3/5 | <0.001 | 0.0011 | 0.0011 | 0.0014 | HL-10-1 | 0/3 | <0.001 | <0.001 | <0.001 | 0.005 |
| o-Xylene | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | 0.0018 | <0.001 | 0.0035 | 10[7] |
| m+p Xylene | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | 0.0043 | <0.001 | 0.011 | 10[7] |
| Total Xylenes | 0/5 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 1/3 | 0.0057 | <0.001 | 0.015 | 10 |
| Cyanide (Total) | 2/5 | <0.005 | 0.011 | <0.005 | 0.033 | HL-99-3 | 1/3 | **1.69** | <0.005 | **5.1** | 0.2 |
| Chemical Oxygen Demand (COD) | 4/5 | <1 | 1.4 | 1 | 2 | HL-90-1 | 2/3 | 10.3 | 4 | 26 | NA |

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-99-1, HL-99-2, HL-99-3.
(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1R.
(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.
(4) Means calculated using the detection limit for non-detected sample results.
(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies. NA indicates no MCL has been promulgated.
(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(7) MCL is for total xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

## TABLE 4-3. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR ALL SAMPLING EVENTS TO DATE

| | Period of Record Downgradient Well Concentrations (mg/L) [1] | | | | | | Comparison Values (mg/L) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Background / Upgradient Wells [2] | | | | |
| Parameter | D.F. [3] | Min. | Mean [4] | Median | Max. | Max. Location | D.F. [3] | Mean [4] | Median | Max. | MCL [5] |
| pH (s.u.) | 112/112 | 7.0 | 7.50 | 7.5 | 8.0 | HL-99-3 | 96/96 | 7.41 | 7.45 | 8.0 | NA |
| Specific Conductance (µmhos/cm) | 110/110 | 178 | 958.7 | 948.5 | 1400 | HL-90-1 | 93/93 | 1481.8 | 937 | 4170 | NA |
| Sulfate | 112/112 | 15 | 134.6 | 131 | 190 | HL-99-1 | 96/96 | 336.1 | 121.5 | 1980 | NA |
| Chloride | 112/112 | 29 | 48.9 | 41 | 190 | HL-10-01 | 95/96 | 31.0 | 25 | 195 | NA |
| Nitrate+Nitrite as N | 106/106 | 4.75 | 8.09 | 8.24 | **11.1** | HL-99-1 | 91/91 | **12.48** | 7.18 | **73** | 10 |
| Arsenic (Dissolved) | 3/111 | <0.005 | 0.0051 | <0.005 | 0.010 | HL-99-3 | 20/98 | 0.0055 | <0.005 | **0.037** | 0.010 |
| Iron (Dissolved) | 36/111 | <0.03 | 0.092 | <0.03 | **1.0** | HL-99-1 | 44/96 | **0.401** | <0.03 | **3.14** | 0.3[6] |
| Nickel (Dissolved) | 0/105 | <0.01 | <0.01 | <0.01 | <0.01 | NA | 20/93 | 0.011 | <0.01 | 0.05 | 0.1 |
| Zinc (Dissolved) | 14/106 | <0.01 | 0.012 | <0.01 | 0.09 | HL-90-1 | 10/93 | 0.010 | <0.01 | 0.03 | 2 |
| 1,1,1-Trichloroethane | 46/184 | <0.001 | 0.0014 | <0.001 | 0.0074 | HL-90-1 | 14/102 | 0.0013 | <0.001 | 0.0057 | 0.2 |
| 1,1-Dichloroethane | 147/184 | <0.001 | 0.0021 | 0.002 | 0.0052 | HL-99-3 | 0/102 | <0.001 | <0.001 | <0.001 | NA |
| Benzene | 0/184 | <0.001 | <0.001 | <0.001 | <0.002 | NA | 26/102 | **0.0058** | <0.001 | **0.077** | 0.005 |
| Bromodichloromethane | 0/184 | <0.001 | <0.001 | <0.001 | <0.001 | NA | 11/102 | 0.0012 | <0.001 | 0.0048 | 0.010 |
| Chloroform | 171/184 | <0.001 | 0.0024 | 0.0023 | 0.0055 | HL-90-1 | 73/102 | 0.0055 | 0.0029 | 0.037 | 0.07 |
| Cis-1,2-Dichloroethene | 57/177 | <0.001 | 0.0012 | <0.001 | 0.0025 | HL-99-1 | 0/97 | <0.001 | <0.001 | <0.001 | 0.07 |
| Dichlorodifluoromethane | 125/184 | <0.001 | 0.0019 | <0.001 | 0.015 | HL-90-1 | 0/102 | <0.001 | <0.001 | <0.001 | 1 |
| Tetrachloroethene (PCE) | 182/184 | <0.001 | **0.0071** | **0.0060** | **0.024** | HL-99-3 | 0/102 | <0.001 | <0.001 | <0.001 | 0.005 |
| Trichloroethene (TCE) | 105/184 | <0.001 | 0.0013 | 0.0011 | 0.0032 | HL-99-3 | 0/102 | <0.001 | <0.001 | <0.001 | 0.005 |
| o-Xylene | 1/177 | <0.001 | 0.0010 | <0.001 | 0.002 | HL-99-1 | 26/97 | 0.0039 | <0.001 | 0.033 | 10[7] |
| m+p Xylene | 1/176 | <0.001 | 0.0010 | <0.001 | 0.002 | HL-99-2 | 25/97 | 0.0035 | <0.001 | 0.025 | 10[7] |
| Total Xylenes | 1/84 | <0.001 | 0.0010 | <0.001 | 0.0013 | HL-90-1 | 8/44 | 0.0051 | <0.001 | 0.053 | 10 |
| Cyanide (Total) | 42/111 | <0.005 | 0.0150 | <0.005 | **0.4** | HL-99-2 | 28/97 | **1.44** | <0.005 | **10.9** | 0.2 |
| Chemical Oxygen Demand (COD) | 66/110 | <1 | 2.86 | 2 | 25 | HL-99-3 | 71/96 | 14.0 | 7 | 75 | NA |

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-99-1, HL-99-2, HL-99-3.
(2) Background / Upgradient wells are: 83-6, HL-06-1, MPC-5, HL-94-1R.
(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.
(4) Means calculated using the detection limit for non-detected sample results.
(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies. NA indicates no MCL has been promulgated.
(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(7) MCL is for total xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

Parameters detected in only downgradient wells include: arsenic, zinc, 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), and trichloroethene (TCE).

(b) The parameters historically detected only in background wells (Table 4-3) are nickel, benzene and bromodichloromethane. Parameters historically detected only in downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE.

(c) Nitrate, iron, benzene, PCE and cyanide were reported at concentrations exceeding MCL criteria in the December 2011 sampling event (Tables 4-1 and 4-2). The MCLs for nitrate, benzene and cyanide were all exceeded in a single upgradient well (MPC-5); the MCL for PCE was exceeded in two downgradient wells (HL-10-1 and HL-90-1); the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).

(d) Historically in these wells, nitrate, arsenic, iron, benzene, PCE, and cyanide have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCL for PCE has been exceeded in only downgradient wells; nitrate, iron and cyanide have exceeded their MCLs in both upgradient and downgradient wells; and the MCLs for arsenic and benzene have been exceeded in only upgradient wells.

(e) Nitrate was detected in all of the December 2011 samples. The MCL of 10.0 mg/L was exceeded in one sample collected in upgradient well MPC-5. Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 12.3 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse affects became apparent. However, nitrate levels in downgradient wells have slowly been increasing since that time.

(f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). Arsenic was detected only in

downgradient well HL-99-3; iron was detected in downgradient wells HL-99-1, HL-99-2 and HL-99-3 and upgradient well MPC-5; nickel was detected only in upgradient well MPC-5; and zinc was detected only in downgradient wells HL-99-1, HL-99-2, and HL-99-3 during December 2011 monitoring (Table 3-1). The detected arsenic and metal concentrations were all at or near their detection limits except for iron in downgradient wells HL-99-2 and HL-99-3 (0.10 mg/L and 0.29 mg/L, respectively) and upgradient well MPC-5 (1.51 mg/L) compared to a detection limit of 0.03 mg/L. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through December 2011).

(g) During the December 2011 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE). PCE was the only VOC to exceed its MCL in downgradient wells (HL-10-1 and HL-90-1). 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, m+p xylenes and total xylenes were detected only in background wells; benzene was the only VOC to exceed its MCL in upgradient wells (MPC-5). Chloroform was the only VOC detected in samples from both downgradient and background wells. All detections of chloroform were well below the MCL of 0.07 mg/L.

(h) Cyanide was detected in two downgradient wells (HL-99-2 and HL-99-3) and one upgradient well (MPC-5) during the December 2011 sampling event. Both downgradient detections were well below the MCL of 0.2 mg/L; however, upgradient well MPC-5 far exceeded the MCL with a concentration of 5.05 mg/L.

Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through December 2011) in upgradient well MPC-5. Historically, downgradient

detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

## 4.2 INTER-WELL PREDICTION INTERVAL ANALYSES

Inter-well prediction interval analyses were used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the December 2011 sampling event). Combining all historical data for the background wells, the Shapiro-Francia Test of Normality was performed for each parameter to determine the distribution of the background data. Inter-well parametric prediction intervals were used when the background data were normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at one half the detection limit. Results of the prediction interval test are summarized in Table 4-4. Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, chloride, 1,1-dichloroethane, cis-1,2-dichloroethane, dichloro-difluoromethane, PCE, and TCE have statistically greater concentrations in downgradient wells than upgradient wells.

## 4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the December 2011 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The results

## TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

| Parameter | Background Wells | | Downgradient Wells | | | | |
|---|---|---|---|---|---|---|---|
| | Distribution [1] | Prediction Limit [2] | HL-10-1 | HL-90-1 | HL-99-1 | HL-99-2 | HL-99-3 |
| pH (s.u.) | Norm (95%) | 6.48 - 8.33 | 7.0 | 7.5 | 7.3 | 7.4 | 7.9 |
| Specific Conductance (µmhos/cm) | Non-Norm | 4114.8 | 1230 | 1100 | 1060 | 796 | 779 |
| Sulfate | Non-Norm | 1866 | 130 | 120 | 150 | 120 | 150 |
| Chloride | Non-Norm | 163.7 | **190** | 140 | 97 | 47 | 51 |
| Nitrate+Nitrite as N | ln-Norm (99%) | 209.8 | 8.9 | 8.8 | 9.4 | 6.6 | 8.3 |
| Arsenic (Dissolved) | Non-Norm | 0.0079 | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 |
| Iron (Dissolved) | Non-Norm | 2.95 | <0.03 | <0.03 | 0.07 | 0.10 | 0.29 |
| Nickel (Dissolved) | Non-Norm | 0.032 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Zinc (Dissolved) | Non-Norm | 0.021 | <0.01 | <0.01 | 0.01 | 0.02 | 0.01 |
| 1,1,1-Trichloroethane | Non-Norm | 0.0054 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| 1,1-Dichloroethane | ND | 0.001 | **0.0019** | **0.0017** | <0.001 | **0.0024** | **0.0011** |
| Benzene | Non-Norm | 0.065 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Bromodichloromethane | Non-Norm | 0.0042 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Chloroform | Non-Norm | 0.036 | <0.001 | <0.001 | 0.0021 | 0.0015 | 0.0019 |
| Cis-1,2-Dichloroethene | ND | 0.001 | **0.0016** | **0.0013** | **0.0016** | <0.001 | <0.001 |
| Dichlorodifluoromethane | ND | 0.001 | **0.0016** | <0.001 | <0.001 | **0.0015** | <0.001 |
| Tetrachloroethene (PCE) | ND | 0.001 | **0.0064** | **0.0057** | **0.0035** | **0.0049** | **0.0037** |
| Trichloroethene (TCE) | ND | 0.001 | **0.0014** | **0.0012** | <0.001 | **0.0011** | <0.001 |
| o-Xylene | Non-Norm | 0.028 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| m+p Xylene | Non-Norm | 0.024 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Total Xylenes | Non-Norm | 0.050 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Cyanide (Total) | Non-Norm | 10.6 | <0.005 | <0.005 | <0.005 | 0.007 | 0.033 |
| Chemical Oxygen Demand (COD) | Non-Norm | 66.5 | 1 | 2 | 1 | <1 | 2 |

(1) Normality was calculated using the Shapiro-Francia test.
Norm (X%) = data normally distributed at X% level of significance.
ln-Norm (X%) = data ln-normally distributed at X% level of significance.
Non-Norm = data not normally or ln-normally distributed at 95% or 99% level of significance.
ND = all background data below detection limits. Value shown is the detection limit.

(2) Prediction limits calculated as follows:
Normal or ln-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)
Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)
ND: any detectable concentrations in compliance wells are considered significant.

**Bold values indicate statistically significant results.**
NA - not analyzed

of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

**TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES**

| Parameter | HL-10-1 | HL-90-1 | HL-99-1 | HL-99-2 | HL-99-3 |
|---|---|---|---|---|---|
| Chloride | No Trend | | | | |
| 1,1-Dichloroethane | No Trend | Decreasing | | Increasing | No Trend |
| Cis-1,2-Dichloroethane | No Trend | Increasing | No Trend | | |
| Dichlorodifluoromethane | No Trend | | | No Trend | |
| Tetrachloroethene (PCE) | No Trend | Decreasing | Decreasing | No Trend | Decreasing |
| Trichloroethene (TCE) | No Trend | Decreasing | | Increasing | |

*Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed.

Chloride and dichlorodifluoromethane are not showing trends in any downgradient well. Cis-1,2-dichloroethane is showing an increasing trend in HL-90-1; according to National Primary Drinking Water Regulations, cis-1,2-dichloroethane is formed as a breakdown product from the reductive dehalogenation of the common industrial solvents TCE and PCE. PCE is showing decreasing trends in downgradient wells. 1,1-Dichloroethane and TCE are showing increasing and decreasing trends in downgradient wells; 1,1-dichloroethane is a breakdown product of 1,1,1-trichloroethane, historically found primarily in wells upgradient of the Helena landfill.

## 4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents regularly exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2 and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events along with

compliance well HL-90-1, now replaced by HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past ten years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-10-1 and HL-90-1 for December 2011. Historically, the PCE concentrations in pumping wells HL-99-1, HL-99-2 and HL-99-3 have shown seasonal fluctuations and decreasing trends over the last several years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0072 mg/L after. Due to low water levels in well HL-90-1, this well was replaced with a new well HL-10-1. PCE concentrations in this new well range from 0.006 mg/L to 0.0065 mg/L from June 2010 to the December 2011 sampling event, within historical range of HL-90-1 values and revealed no trend during statistical analysis.

Nitrate concentrations in monitoring wells that have exceeded the MCL of 10 mg/L in the past ten years or are showing an increasing trend are shown on Figure 4-2. The concentrations of nitrate in downgradient wells HL-90-1, HL-99-1 and HL-99-3 have shown slight increasing trends over the last several years; the MCL was exceeded in wells HL-99-1 twice and HL-99-3 once in the last three years. The MCL for nitrate was not exceeded in any downgradient wells during the December 2011 sampling event.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well with the December 2011 concentration at 12.3 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This

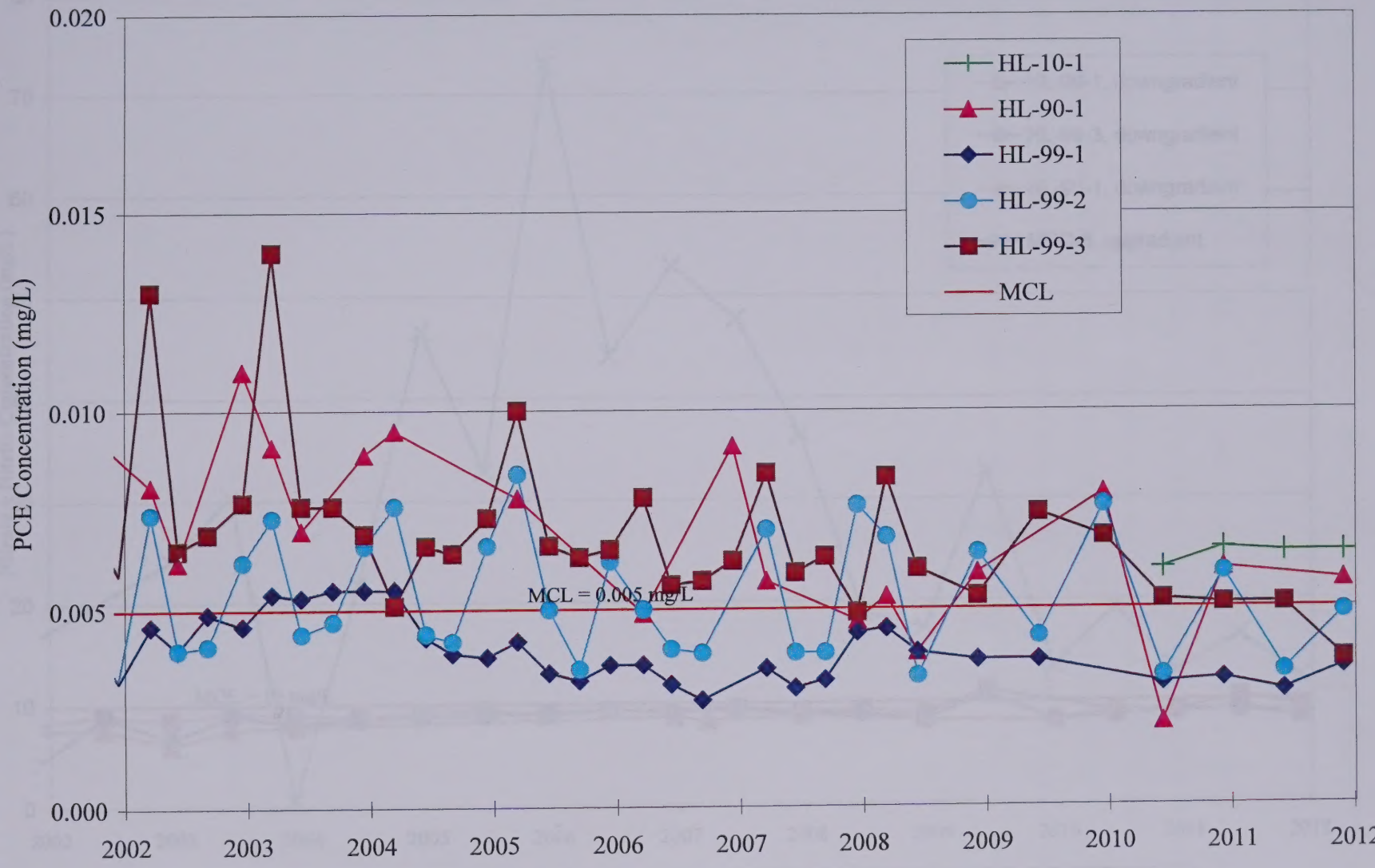
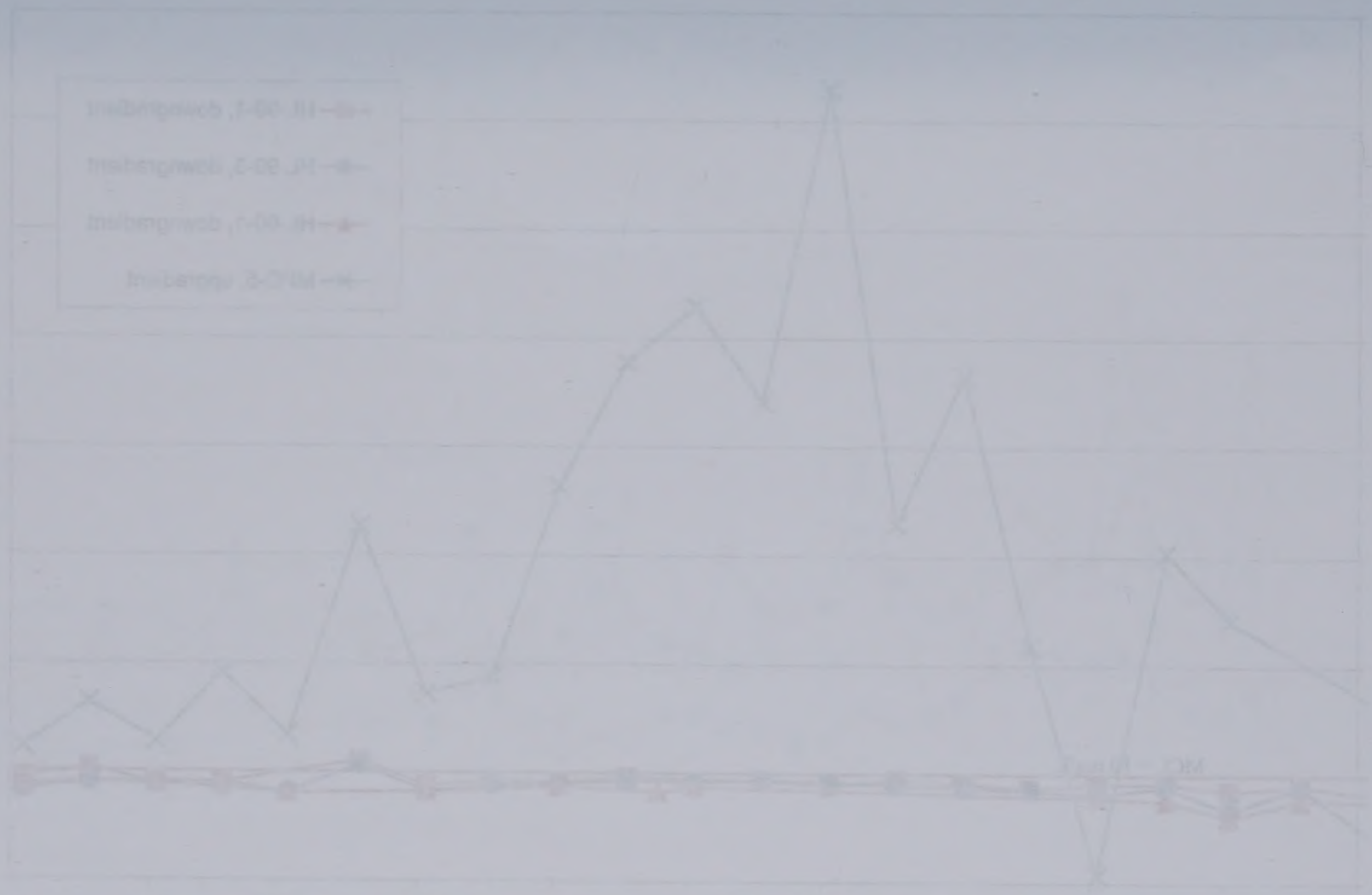



**Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells**

0.020
0.015
0.010
0.005
0.000
TCE Concentration (mg/L)

**Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells**



pilot program was shut down when these adverse affects became apparent; however, nitrate levels are still increasing downgradient of the former coal degasification plant.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

# 5. DOMESTIC WELL DATA EVALUATION

Two domestic wells were also sampled during the December 2011 sampling event. For wells 5 and 16, the only concentrations of VOCs reported above the detection limit were for chloroform and PCE; all detections were below their respective MCLs. Trends in PCE concentrations over the last ten years for the sampled domestic and irrigation wells are shown on Figure 5-1. Both of these wells are used only for irrigation, and residential homes related to these domestic wells have been connected to the City water supply.

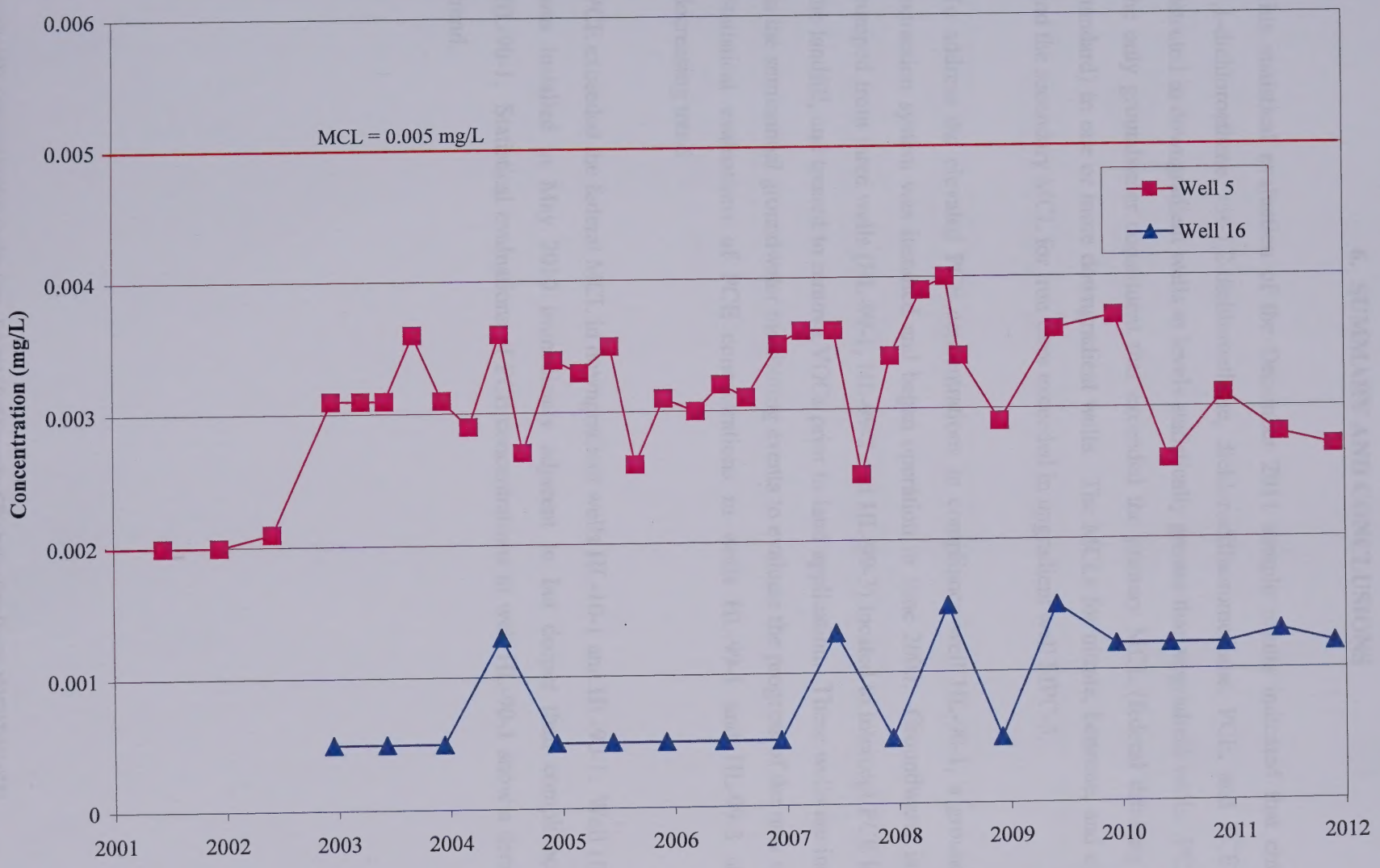



**Figure 5-1. Temporal Trends in PCE Concentrations in Domestic and Irrigation Wells**

Concentration (µg/L)
0
100
200
300
400
500
600
700
800
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

# 6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the December 2011 sample results indicated that chloride, 1,1-dichloroethene, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE were detected in downgradient wells at levels statistically greater than upgradient wells. PCE was the only groundwater constituent that exceeded the primary MCL (federal drinking water standard) in one or more downgradient wells. The MCLs for nitrate, benzene, and cyanide and the secondary MCL for iron were exceeded in upgradient well MPC-5.

To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2 and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Statistical evaluations of PCE concentrations in wells HL-99-1 and HL-99-3 show a decreasing trend.

PCE exceeded the federal MCL in downgradient wells HL-10-1 and HL-90-1. Well HL-10-1 was installed in May 2010 immediately adjacent to but deeper than compliance well HL-90-1. Statistical evaluations of PCE concentrations in well HL-90-1 show a decreasing trend.

# 7. REFERENCES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# APPENDIX A

# DATA VALIDATION REPORT

# DATA VALIDATION REPORT
# GROUNDWATER QUALITY DATA
# SEMI-ANNUAL SAMPLING
# DECEMBER 2011

# CITY OF HELENA LANDFILL

**Prepared For:**

## CITY OF HELENA

**HELENA, MONTANA**

**Hydrometrics, Inc.**
consulting scientists and engineers

**JANUARY 2012**

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# GROUNDWATER QUALITY DATA
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## CITY OF HELENA LANDFILL

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JANUARY 2012

# DATA VALIDATION REPORT
# CITY OF HELENA LANDFILL

**Groundwater Samples Collected in**

**December 2011**
**(Semi-Annual Sampling)**

Prepared by
Hydrometrics, Inc.
3020 Bozeman Avenue
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JANUARY 2012

# DATA VALIDATION REPORT

# CITY OF HELENA LANDFILL

Groundwater Samples Collected in

December 2011

(Semi-Annual Sampling)

Prepared by

HydroSolve, Inc.

1020 Bowman Avenue

Helena, MT 59601

JANUARY 2012

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## GLOSSARY OF TERMS

CCB .....Continuing Calibration Blank

CCV .....Continuing Calibration Verification

CLP .....Contract Laboratory Program

CRDL.....Contract Required Detection Limit

FAA .....Flame Atomic Absorption

GFAA.....Graphite Furnace Atomic Absorption

HGAA.....Hydride Generation Atomic Absorption

ICB.....Initial Calibration Blank

ICP .....Inductively Coupled Plasma

ICV.....Initial Calibration Verification

IDL.....Instrument Detection Limit

LCS .....Laboratory Control Sample

MSA.....Method of Standard Additions

PB.....Preparation Blank

PRDL .....Project Required Detection Limit

QAPP .....Quality Assurance Project Plan

QC.....Quality Control

RPD.....Relative Percent Difference

RSD.....Relative Standard Deviation

SOW.....Statement of Work

TDS.....Total Dissolved Solids

## SUMMARY

Laboratory analysis for groundwater samples collected for the December 2011 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

**Violations involving field quality control samples:**

- In the field rinsate blank, HL-1112-104 one exceedance occurred for chloroform resulting in one associated data result being flagged.

**Violations involving laboratory quality control samples:**

- In the QA/QC Summary Report provided by Energy Laboratories, matrix spike and matrix spike duplicate review showed several exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.
- It should also be noted that Energy Laboratories raised the reporting limit of sulfate, nitrate + nitrite as n, and cyanide due to sample matrix interference. The reporting limits used for dissolved antimony and thallium were lower than the requested limits, and did not seem to impact the results.
- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.
- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, and cyanide. However, no associated

data was flagged because the methods used are considered comparable to stated methods in work plan.

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 99 percent of the field quality control sample results were within control limits and 97 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this data review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; a brief summary of flagged data is in Table 2; and a historical comparison is in Table 3. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

# DATA VALIDATION REPORT

## 1. INTRODUCTION

This validation applies to organic analytes for 24 water samples collected for the City of Helena Landfill semi-annual monitoring project during the December 2011 sampling event. The total number of samples included: ten field observations, one field duplicate, two field blanks (DI and Rinsate) and one trip blank.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

| SITE CODE | SAMPLE NUMBER | WATER LEVEL | FIELD PARAMETERS [1] | METALS AND COMMONS [2] | VOLATILES METHOD 8260 [3] |
|---|---|---|---|---|---|
| HL-94-1R | HL-1112-100 | X | X | X | X |
| HL-10-01 | HL-1112-101 | X | X | X | X |
| HL-10-01 DUP | HL-1112-102 | | | X | X |
| HL-06-1 | HL-1112-103 | X | X | X | X |
| RINSATE BLANK | HL-1112-104 | | | X | X |
| HL-99-1 | HL-1112-105 | X | X | X | X |
| HL-99-2 | HL-1112-106 | X | X | X | X |
| HL-99-3 | HL-1112-107 | X | X | X | X |
| HL-90-1 | HL-1112-108 | X | X | X | X |
| MPC-5 | HL-1112-109 | X | X | X | X |
| DI BLANK | HL-1112-110 | | | X | X |
| TRIP BLANK | HL-1112-111 | | | | X |
| 82-3 | HL-1112-112 | X | | | |
| EPA-1 | HL-1112-113 | X | | | |
| HL-90-2 | HL-1112-114 | X | | | |
| HL-90-3 | HL-1112-115 | X | | | |
| HL-94-2R | HL-1112-116 | X | | | |
| HL-94-3 | HL-1112-117 | X | | | |
| I-1 | HL-1112-118 | X | | | |
| INF GALLERY | HL-1112-119 | X | | | |
| MPC-1 | HL-1112-120 | X | | | |
| MPC-2 | HL-1112-121 | X | | | |
| Res #16 | HL-1112-200 | | X | X | X |
| Res #5 | HL-1112-201 | | X | X | X |

1.) Field parameters include pH, SC, and water temperature.
2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.
3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:
  (Check all that apply)
  _X_ EPA CLP National Functional Guidelines for Inorganics Data Review
  _X_ EPA CLP National Functional Guidelines for Organic Data Review
  _X_ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)

- Overall level of validation:
  ___ Contract Laboratory Program (CLP)
  _X_ Standard (see following notes)
  ___ Visual

  **NOTES**: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

## 2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.
  _X_ Yes (see following notes)
  ____ No

  **NOTES**: The following was noted on the Workorder Receipt Checklist upon samples arrival at Energy Labs;
  - Sample HL-1112-200 did not have a collection time on the sample containers – time was used off the Chain of Custody.
  - Sample HL-1112-109 had to be preserved in lab upon receipt for nitrate + nitrite as n and chemical oxygen demand with 4 ml sulfuric acid to acidity for a pH <2.

- All documentation of field procedures was provided as required.
  _X_ Yes
  ___ No

- Consistency with project requirements
  Sampling was completed in order as stated in the SAP.
  _X_ Yes (see following notes)
  ____ No

  **NOTES**: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

## 3. FIELD QUALITY CONTROL SAMPLES

- **Field blanks**

  Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

  DI, trip, rinsate, or any other field blanks have been carried out at the proper frequency.

  _X_ Yes

  ___ No

  Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

  ___ Yes

  _X_ No (see the following notes)

  **NOTES**: In field blank sample HL-1112-104 one exceedance occurred for chloroform resulting in one associated result being flagged.

- **Field duplicates**

  Field duplicates have been collected at the proper frequency.

  _X_ Yes

  ___ No

  Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within ± the PRDL for water matrix, within ± 2 times the PRDL for soil matrix.

  _X_ Yes

  ___ No

- **Field standards**

  Field standards were sent at the proper frequency

  ___ Yes

  ___ No

  _X_ NA - Not required by the work plan.

## 4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

  ___ CLP-SOW

  _X_ SW-846

  _X_ Methods for Chemical Analysis of Water and Wastes

  ___ XRF Standard Operating Procedures

  ___ Other

- **Samples were received by the laboratory at the proper temperature**

  _X_ Yes

  ___ No

- **Holding times met**

  ___ Yes

  _X_ No (see the following notes)

  **NOTES:** Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately",

but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.

- **Consistency with project requirements**

  Analyses were carried out as requested.
  _X_Yes
  ___No

  Project specified methods were used.
  _X_Yes (see following notes)
  ____No

  **NOTES:** It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, and cyanide. However, no associated data was flagged because the methods used are considered comparable to stated methods in work plan.

## 5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).
  _X_Yes (see following notes)
  ____No

  **NOTES**: It should be noted that Energy Laboratories raised the reporting limit for sulfate, nitrate + nitrite as n, and cyanide due to a sample matrix interference. The reporting limits used for dissolved antimony and thallium were lower than the requested limits, and did not seem to impact the results.

## 6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

  Preparation/Method blanks were prepared and analyzed at the required frequency.
  _X_Yes
  ___No

  All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).
  _X_Yes
  ___No

## 7. LABORATORY BLANK SPIKES

- **Blank Spikes**

  Blank spikes (organics) were prepared and analyzed at the required frequency.
  _X_Yes
  ____No

Blank spike recoveries were within control limits.
_X_ Yes
___No

## 8. SURROGATE SPIKES

- **Surrogate Spikes**

Surrogate spikes were prepared and analyzed at the required frequency.
_X_ Yes
____No

Surrogate spike recoveries were within control limits.
_X_ Yes
___No

## 9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.

_X_ Yes
____No

Matrix spike recoveries were within control limits.
___Yes
_X_ No (see following notes)

- Matrix spike duplicate samples were analyzed at the proper frequency.

_X_ Yes
____No

Matrix spike duplicate RPD's were within control limits.
___Yes
_X_ No (see following notes)

**NOTES**: Both matrix spike and matrix spike duplicate samples had several QC exceedances. At this level of validation, these exceedances are only noted and no flagging of the associated data occurs.

## 10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from the December 2011 monitoring:

_X_ Lab SC versus field SC
_X_ Lab pH versus field pH

**Lab SC versus field SC:** A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes, showed that all of the SC pairs exceeded the ten percent comparison criteria.

**Lab pH versus field pH:** A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes, showed that also none of the pH pairs exceeded the ten percent comparison criteria.

## 11. HISTORICAL COMPARISON

Current sampling event data (December 2011) were compared to historical data (December 2007 through November 2011). The data for the December 2011 sampling event was similar to historic data.

## 12. DATA QUALITY OBJECTIVES

- **Project data quality objectives (DQO's) met.**

  _X_ Yes
  ___ No

**Accuracy**

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

**Precision**

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 97 percent for this sampling event.

Field precision was 99 percent for this sampling event.

**Completeness**

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

**DATA VALIDATION REPORT**

**Prepared by: Ericka Vallance**

**Reviewed by: Jodi Bingham, P.E.**

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Validation and Stati
Evaluation of December 2011
Groundwater Quality Data
City of Helena Landfill
Appendix A - Data Validation
February 2012
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# APPENDIX B

# STATISTICAL ANALYSIS REPORTS

Data Validation and Statistic
Evaluation of December 2011
Groundwater Quality Data

City of Helena Landfill

Appendix B - Statistical Analysis Reports

February 2012

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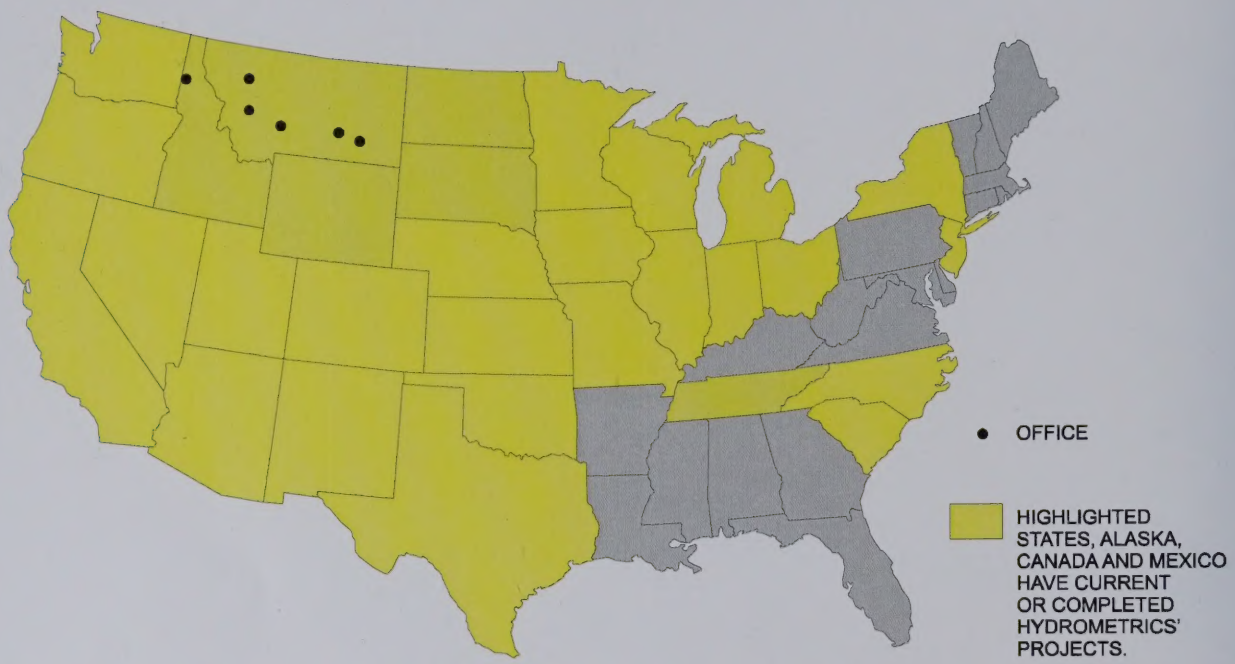


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